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Cartesian Economics

The Bearing of Physical Science upon State Stewardship. By *Frederick Soddy, M.A., F.R.S.*

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Cartesian Economics.

THE BEARING OF PHYSICAL SCIENCE UPON STATE STEWARDSHIP.

Two Lectures to the Student Unions of Birkbeck College and The London School of Economics, November 10th and 17th, 1921.*

By Frederick Soddy, M.A., F.R.S.

FIRST LECTURE.—Chairman, Sir Richard Gregory.

IT is my intention to try to bring the existing knowledge of the physical sciences to bear upon the question "How do men live?" This question ought to be the first the economist should try to answer. I am by no means the first to essay this task, but the modern economist seems to have forgotten that there is such a question, whilst the earlier ones lived at a stage of the development of scientific knowledge when no exact answer was forthcoming.

My own point of departure could not be better illustrated than by a quotation from Descartes, and the aspects I propose to examine might well be called "Cartesian Economics."

> "Starting from the forms of knowledge most useful to life, instead of from that speculative philosophy taught in our schools, and knowing the force and processes of fire, the air, the stars and all the other bodies which surround us as distinctly as we know the different occupations of our own workmen, we shall be able to employ them in the same fashion and so render ourselves as the masters and possessors of nature and contribute to the perfection of the human life."

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* These lectures owe much to a long controversial correspondence carried on with Dr. H. Lyster Jameson, whose sad death is just reported in the papers. Dr. Jameson upheld the neo-Marxian or proletarian view in economics and the determinist or, as I style it, the "ultra-materialistic," philosophy, and from the controversy my own views gained in definiteness and clearness.

March 3rd, 1922. F. S.

The enormous progress made in the mastery of man over nature and the meagre contribution to the perfection of the human life is a contrast that can only be accounted for by some such enquiry as that which I propose to essay. But in language more homely than that of Descartes I may illustrate my starting point by means of a story. An expert organist, drawing enthusiastic applause from his audience, was surprised and annoyed by the blower coming to the front of the screen and remarking to him, "Yes! we played that piece very well" The blower not being encouraged in well-doing, in the next piece the divine music rose majestically to its climax and then petered out in a dismal wail, whilst a head appeared round the screen and remarked, "*Now*! is it we?" Nor is it without significance to note that, since the occurrence, the human labour upon which the organist relied has been replaced so completely by electric power. Power, rather than any qualifying adjective, human, mechanical or electrical, is the starting point of Cartesian economics.

At the risk of being redundant, let me illustrate what I mean by the question, "How do men live?" by asking what makes a railway train go. In one sense or another the credit for the achievement may be claimed by the so-called "engine-driver," the guard, the signalman, the manager, the capitalist, or the share-holder,—or, again, by the scientific pioneers who discovered the nature of fire, by the inventors who harnessed it, by Labour which built the railway and the train. The fact remains that all of them by their united efforts could not drive the train. The real engine-driver is the coal. So, in the present state of science, the answer to the question how men live, or how anything lives, or how inanimate nature lives, in the sense in which we speak of the life of a waterfall or of any other manifestation of continued liveliness, is, with few and unimportant exceptions, "By sunshine." Switch off the sun and a world would result lifeless, not only in the sense of animate life, but also in respect of by far the greater part of the life of inanimate nature. The volcanoes, as now, might occasionally erupt, the tides would ebb and flow on an otherwise stagnant ocean, and the newly discovered phenomena of radioactivity would persist. But it is sunshine which provides the power not only of the winds and waters but also of every form of life yet known. The starting point of Cartesian economics is thus the well-known laws of the conservation and transformation of

energy, usually referred to as the first and second laws of thermodynamics.

But let us, before starting on this quest, go to the other extreme and try to obtain a consistent mental picture of the whole of knowledge and the inter-relationship of the sciences, if only to rebut two, in my opinion, errors, caricatured rather than described by the terms "Mechanistic" and "Vitalistic" in philosophy. In any classification of the sciences it is customary to distinguish three great groups, (1) the Mechanical, Physico-Chemical and Mathematical; (2) the Biological; and (3) the Mental, inter-related much as in the order enumerated, like the links of a chain, two end links and a middle link, and the latter, the great division of animal and vegetable life, alone in direct relation to the two ends.

Without perhaps any more quantitative notion than that the subjects enumerated in the list are in order of cognateness, one may regard the first link of the chain as commencing with the present ultimate realities of physics—Electricity, Energy, Ether, and Matter in increasing complexity from the element to the complex colloid, actuated by the liveliest Brownian movement under the microscope, and yet not alive. The second link begins with the simplest unicellular form of life and stretches in ever-increasing complexity from amoeba to man. The third begins with rudimentary forms of instinctive behaviour closely allied to those produced by purely physical stimuli in simple creatures, through free-will and the deliberate choice of action to secure predetermined ends, up to the human reason and the highest intellectual, aesthetic, ethical, moral and spiritual perceptions of humanity.

My own philosophy can be expressed by a line of Kipling—

"East is East and West is West and never the twain shall meet."

One thousand years hence it is certain, if civilisation lasts as long, that men will still be examining into the fundamental realities of the physical world, far beyond the world of atoms and energy which marks its present boundary. Equally, we may believe that they may in psychological enquiry and in spiritual perceptions be much advanced from our time. In each direction possibilities of further knowledge extend *ad infinitum*, but in each direction diametrically away from and not towards the problems of life. It is in this middle field that economics lies, unaffected whether by the ultimate philosophy of the

electron or of the soul, and concerned rather with the *interaction* with the middle world of life of these two end worlds of physics and mind in their commonest everyday aspects, matter and energy on the one hand, obeying the laws of mathematical probability or chance as exhibited in the inanimate universe, and, on the other, with the guidance, direction and willing of these blind forces and processes to predetermined ends. The physicist claims that his world of matter and energy exists as a reality independent of life, and points to the laws of conservation to show that it is eternal, without beginning and without end, and to the record of the rocks to show that it is life, rather than the universe of nature, which began. The theologian and religious philosopher claims under the name of Deity the independent and eternal existence of the qualities of guidance, will and direction outside of life, and points to this to account for the ascending scale of evolution and the appearance of perceptions above the level of animal. I have no claim or call to express an opinion on the reality of the existence of intelligence apart from and outside of life. But that life is the expression of the interaction of two totally distinct things represented by probability and free-will is to me self-evident, though the ultimate nature of those two different things will probably remain, a thousand years hence, as far off as ever.

It is simple now to indicate what to my mind are the two errors that hinder progress. Both are monistic obsessions due to the mind in its innate desire to reduce everything to its simplest terms ending by trying to reduce everything to its simplest term. The first links up the two ends of the chain running in diametrically opposite directions into a grand circle, and so gets the sublimated conceptions of the mental world inextricably mixed up with the physical. The oriental philosophies and religions seem to have been freer from the cruder forms of this confusion than our own. In the early forms deities were given physical powers analogous to those of trinitrotoluene, as for example the hammer of Thor and the thunderbolt of Jove. The idea that the physical universe must, like life, have had a beginning and therefore a creator still survives. Heaven to the ordinary man is at once the abode of disembodied souls and of constellations which perform their evolutions with such mathematical accuracy that events therein can be accurately predicted in advance. Its most recent phase is the theosophistical enquiry by occult powers into the internal

structure of the atom and the prevalent belief that the discovery of wireless telegraphy lends strong support to the reality of telepathy.

The second error is perhaps more common in the sphere of economics. It may be called " Ultra-Materialism " and is the attempt to derive the whole of the phenomena of life by continuous evolution from the inanimate world. We begin with a nebula of primordial material condensing into ever more complex forms, first to the light and then the heavy elements, then to chemical compounds up to the complex colloid. By a continuation of the same processes such a complex results that it is continually decomposing and as continually regenerating itself. The inanimate molecules begin to live and life then runs through its course of evolution up to man. This may satisfy a biologist, but it fails to satisfy me as a chemist. I cannot conceive of inanimate mechanism, obeying the laws of probability, by any continued series of successive steps developing the powers of choice and reproduction any more than I can envisage any increase in the complexity of an engine resulting in the production of the " engine-driver " and the power of its reproducing itself. I shall be told that this is a pontifical expression of personal opinion. Unfortunately, however, for this argument, inanimate mechanism happens to be my special study rather than that of the biologist. It is the invariable characteristic of all shallow and pretentious philosophy to seek the explanation of insoluble problems in some other field than that of which the philosopher has first-hand acquaintance. The biologist has first-hand knowledge of animate mechanism and seeks the origin of it in colloid chemistry. The test of the hypothesis is not so much what the biologist as what the chemist has to say about it. The difference to my mind between dead and living matter is much that between Niagara Falls thirty years ago and now, and is not to be explained by the laws which Niagara formerly obeyed, by the laws of pure probability, but by their opposite, the operations of intelligence, as typified in their most rudimentary form by Clerk-Maxwell's conception of the " sorting-demon."

Life, or animate mechanism, is essentially to my mind a dualism, and any attempt to subordinate either partner is fatal. But the economist is peculiarly liable to mistake for laws of nature the laws of human nature and to dignify this complex of

thermodynamical and social phenomena with the term "inexorable economic law."

Is it any wonder that such crude confusions, such triumphs of mental instincts over reason, experience and common sense, have produced a general sterility of constructive thought? I cannot do better to illustrate this than to quote Stephen Leacock in his most serious mood, and if it be objected that he is a humorist, I can only retort that he is a professor of economics. It is rather the avowal of the combination that is uncommon.

> "Our studies consist only in the long-drawn proof of the futility of our search after knowledge effected by exposing the errors of the past. Philosophy is the science which proves that we can know nothing of the soul. Medicine is the science which tells us that we know nothing of the body. Political Economy is that which teaches that we know nothing of the laws of Wealth, and Theology is the critical history of those errors from which we deduce our ignorance of God.
>
> "When I sit and warm my hands, as best I may, at the little heap of embers that is now Political Economy, I cannot but contrast its dying glow with the vainglorious and triumphant science that once it was."

Against this I would put the paradoxical words of Poincare discussing the doctrine of mathematical probability, which dominates the inanimate world.

> "You wish me to tell you about these complex phenomena. If by ill luck I happened to know the laws which govern them I should be helpless. I should be lost in endless calculations and could never supply you with an answer to your questions. Fortunately for both of us I am completely ignorant about the matter. I can therefore supply you with an answer at once. This may seem odd. But there is something odder still, namely, that my answer will be right."

It is perhaps fortunate that we know nothing about the ultimate nature of the fundamentals of either the physical or mental worlds. We have pursued each so far as to know that both alike lead away from rather than toward the solution of the problems of life. The sublimated theoretical concepts in either case have long ceased to possess actuality. We have rather to find the interaction between their commonest forms, matter and energy on the one hand and will and direction on the other.

Let us now leave generalities and concentrate upon the question as to what precisely humdrum mechanical science can contribute to economics. It insists primarily on the fact that life derives the whole of its physical energy or power, not from anything self-contained in living matter, and still less from an external deity, but solely from the inanimate world. It is dependent for all the necessities of its physical continuance primarily upon the principles of the steam-engine. The principles and ethics of human law and convention must not run counter to those of thermodynamics. For men, no different from any other form of heat engine, the physical problems of life are energy problems. You have to consider the source, the sunshine. It supplies a continuous revenue of energy which is *consumed* by the living engine in its life. Consumption here does not mean destruction, for destruction, like creation in the world of which we speak is an absurdity, but merely the rendering unfit for further use. All the radiant energy received from the sun sooner or later finds its way into the great energy sink, the ocean of heat energy of temperature uniform with the surroundings, and is incapable of any further transformation. This is the form we know most about. It is the energy of the perpetual thermal agitation of the molecules of which Poincaré spoke, and of which we know nothing (of any individual molecule's motion) and yet know everything (of the statistics of the motion as a whole). And, it is useless.

We have next to consider the transformation of the form in which nature supplies the energy into the form men can utilise and assimilate. In general, transformation of energy can proceed only in the one direction, much as water only runs downhill. The water may do useful work on the way turning waterwheels, or it may not, but may reach the ocean level quite unutilised. So of the revenue of sunshine which ultimately warms imperceptibly the whole mass of the globe, it may *en route* energise a man, or, again, it may not.

As regards the utilisation you have to distinguish very carefully in Cartesian economics two uses. First, there is the fundamental metabolic use in the body for the life process, which I shall for brevity term *life-use*. Secondly, there is a use in lieu of the first for the doing of external work or labour, better done directly by inanimate energy. This I shall term the *labour-use*.

Physically, the life-problem is the reversal of winding a clock. Before any man can confer the animation of his body

upon a mechanism as in clockwinding, the animation of nature's mechanism has first to be conferred upon him. History could be rewritten from the standpoint of how this has been done. At first it was done blindly and intuitively by trial and error, the survival of the fittest and the extravagantly wasteful methods that only the unconquerable resurgence of life can afford. Even now the process is so indirect, being only possible through the agency of vegetable life, that few realise the terms on which they exist or the supreme importance of the original sources and amounts of energy available.

But the labour-use of natural energy has always been a matter of consciously directed effort and development, since the use of the wind in navigation, and had proceeded far before the formulation of the principles of energetics. But in neither case is the sudden break in the continuity of history, which marked the age of steam, explained by these developments. The key is to be found in this. Pre-nineteenth century man lived on revenue. Present day man augments the revenue within certain well-defined limitations out of capital.

All forms of energy previously utilised by life, with one or two minor exceptions, as tidal energy and that of hot springs, were forms of the solar revenue. Wind-power, water-power and wood fuel are parts of the year-to-year revenue of sunshine no less than cereals and other animal foods. But when coal became king, the sunlight of a hundred million years ago added itself to that of to-day and by it was built a civilisation such as the world had never seen.

The fundamental fact underlying this civilisation is that whilst men can lighten their external labours by the aid of fuel-fed machinery, they can only feed their internal fires with new sunshine and then only through the good offices of the plant. The vegetable world alone can transform the original flow of inanimate energy into vital energy. The animal, as yet, is constitutionally incapable of effecting this transformation.

The technical features of this subject are not without significance. Whatever the origin of the energy, the penultimate step must always be its storage by the plant precedent to its use by animals for food. It is possible to draw upon the energy of a water-fall and to store it up in various chemical compounds by electro-chemical methods, and in this form to supply it as a fertiliser to the plant. Increased crops are so produced supporting an increased population. The reversal of clock-

winding has been consciously achieved. The falling weight of Niagara's waters work the man. There is no technical objection to utilising the energy of coal in the same way, other than that of prime cost. But for practical purposes it is true that the great capital store or energy in fuel is not yet utilised for the life-use, but only primarily for the labour-use of energy by life. The life-use demands the intermediary of the plant, and though coal was once alive it is long since dead. The laborious and wasteful travail, through farming and agriculture, has once again to be gone through. In spite of the striking advances of the past century, the agriculturalist, peasant and farm-labourer form the dominant economic class, and will remain so until some new discovery of science deposes them. To my mind this is one of the least obvious and yet most fundamental facts of economics and social science at the present time.

It certainly has not been sufficiently realised by economists, particularly in this country. In the flamboyant period of the utilisation of the capital store of energy in fuel which is now closing, so far at least as this country is concerned, we could and did by machinofacture make almost every sort of commodity and all sorts of labour-saving machinery in exchange for the food which we could not so make and did not make. The population of Great Britain rose on account of this exchange of capital for revenue, of factory products for food, from 10·5 millions in 1801 to 40·9 millions in 1911. Whereas in Ireland, which has not coal, it fell from 5 to 4·3 millions over the same period. Cartesian economics is capable of diagnosing instantly the root of the Irish trouble, as Sir Leo Chiozza Money has pointed out.

By this process of exchange of factory products the whole world gradually drew more and more for its labour-use upon the capital energy of fuel, and used it to widen the area under cultivation and to transport the harvests from the most distant regions of the globe and so *indirectly* augmented the revenue of sunshine upon which it is still entirely dependent for its life-use.

But this is a very passing phase. New countries grow old. Their populations tend to expand to the limit of their food supply, and their industries and manufactures become developed by the aid of their own resources. For a double reason, therefore, the flamboyant period of prosperity through which

Great Britain has passed is destined to be short-lived. "Imperialism" marks its final bid for survival.

Coal is the real capital, out of the consumption of which the capitalist civilisation has been built up, but, as regards the means of livelihood of the swollen population that has accompanied its exploitation, its use in this respect has been indirect and will cease. This is the great paradox of Capitalism. It is capitalistic as regards the accessories, conveniences and luxuries of existence. As regards its necessities it is still, to coin a word, revenual. Even Adam Smith could say, "When food is provided it is easy to find the necessary clothing and lodging." To-day, by the development of mechanical power, it is vastly easier than then. But, once this has done all it can to develop new countries and increase the food supply, it can meet the demand for bread only by offering a stone. True, by the advances of chemical and biological science, by the development of agricultural chemistry and the breeding of better brands of wheat, much may be done, but scarcely as much as will provide for the requirements of a four or five-fold increase of population.

The industrialised countries are, with an enthusiasm reminiscent of a lunatic asylum, turning out an ever-increasing plethora of mere factory products and sending them forth to compete in ever-shrinking markets in exchange for food, and are pouring forth an ever-increasing stream of armaments to fight amongst themselves for markets. The only goal in sight is war and yet war, the blowing up of the plethora and the permanent devitiation of the stock of the white race, at the time, too, when, by reason of failing fecundity, the prospect of its having to fight about something other than markets is becoming evident.

Physical science thus answers precisely, and, I think for the first time, *the* problem of political economy, or, as one Marxian writer puts it, "What are the sources of our society's wealth, that is, the means of subsistence and comforts of the individuals comprising it?" The means of subsistence are derived from the daily revenue of solar energy, through the operations of agriculture. The accessories of life, clothes, houses and fuel, as well as its comforts and luxuries, are derived in great part by the augmentation of this revenue out of a capital store of energy preserved from bygone geological times. Life depends from instant to instant on a continuous flow of energy, and

hence wealth, the enabling requisites of life, partakes of the character of a flow rather than a store.*

This answer, though of fundamental importance to social science and to political philosophy, has little application to present economical systems, because these are founded upon a simple confusion between wealth and debt, or, to put it another way, between the wealth of the community and the wealth of the individual member of the community.

The wealth of the community is its revenue, which, in the last analysis, is a revenue of energy available for the purposes of life. That being given, in sufficient amount and in form capable of being utilised by the existing knowledge of the time, *everything* requisite for the life of the society can be maintained. It is impossible to save or store this flow to any appreciable extent. True, you can dam a river, at great expense, and make a reservoir. But, even if not used, the accumulated waters evaporate and leak away. You can under the same, but even more unfavourable terms, store electric energy. But to contemplate storing wealth on a national scale for even a day is something like contemplating a storage battery large enough to satisfy the demand of the world for electric power for one day. True, nature has stored it in coal by processes requiring geological epochs, but what we do is to *unstore* it, an easier matter, and to convert it into a flow before it is of the least possible use to us. Again, for short periods, the flow may be embodied in

* Had Karl Marx lived after instead of before the establishment of the modern doctrine of energy there can be little doubt that his acute and erudite mind would easily have grasped its significance in the social sciences. As it was, in fairness to him it must be said that he did not attempt to solve the real nature of wealth, but concentrated entirely upon the problem of its monetary equivalent, that is, upon *exchange-value* rather than *use-value*.

Lest I be misunderstood I may emphasise here that I am using the term *energy* throughout these lectures in the strictest scientific sense, for potential or kinetic energy as understood by the physical scientist and engineer, and never in the vague and misleading sense of "mental energy" which I have rather termed the guidance and direction of physical energy. In this strict sense of the word it cannot be maintained that wealth wholly originates in human labour, for there is no real distinction in physical science between animate and inanimate energe. But since wealth is not available energy merely, but rather available energy usefully directed, or some embodiment of it, himan "labour" (that is, some form or intelligent human activity which may need only a minimum or physical energy) is usually, though not necessarily, an essential factor in its creation.

some concrete commodity, in food which rots, in houses which fall into desuetude if not kept perpetually under repair, and in all the tangible assets of our civilisation, in railroads, roads, and public works, factories, wharves, shipping and the like. All alike are subject to a process of compound decrement, needing ever larger annual expenditure of new wealth to maintain them in order, and even then rapidly, with each fresh advance of science, becoming out of date. Such accumulated assets, at best, are classified not as accumulated wealth, but as aids and accessories in the maintenance and increase of wealth out of the available revenue of energy. The wealth is the revenue, *and it cannot be saved.*

The wealth of an individual, on the other hand, is something totally different. The ordinary modern individual member of the community in the vast majority of cases does not possess enough wealth to keep him alive for a week. By means of a token, legalised as a form of currency, whether a cowrie stone or a metal counter, but now, more and more exclusively, a simple paper note, the community acknowledges its indebtedness to the holder of the token, and empowers the individual to indent upon the revenue of real wealth flowing through the markets at any time. Even at this stage we see the interests of the community opposed diametrically to those of the individual members. As Ruskin puts it, it is the rule and root of all economy that what one person has, another person cannot have, and the more the private individual is able to indent upon the revenue the less is left for public services and the carrying on of enterprises designed to increase the revenue for the general benefit rather than private profit. The concern of the scientific man is with the revenue and with how it may be increased in the directions most essential for the general well-being. If and in so far as political economy can claim to be a science, that, also, should be its first concern. The individual, on the other hand, is concerned only to obtain a larger share of the revenue for his own private use. In so far as he can only do so by increasing, or aiding in increasing, the real revenue of wealth for the purpose of use rather than of usury the community gains. A very real complaint that the worker has with the existing system is that it provides much more easy and lucrative means of making money without any contribution to the general wealth, and sometimes actually by destroying it, by individuals possessed of sufficient of the power conferred by money to hold up the revenue for usury.

Ruskin appears to have had a very much clearer conception of the real nature of wealth than either earlier or later economists. He pointed out, and his view would now be understood by anyone who has suffered from the dearth of servants on account of the war, that the art of becoming rich was to get more *relatively* than other people, so that those with less may be available as the servants and employees of those with more. In this acute and original analysis of the real nature of the individual's wealth—power over the lives and the labour of others—Ruskin disclosed probably the most important difference between the interests of the individual and the interest of the State, and the main reason why the mastery of man over nature has hitherto resulted in so meagre a contribution to the perfection of human life. For this reason the community in its struggle with nature resembles an army officered almost entirely by the enemy. Of what use are the discoveries of scientific men into new modes and more ample ways of living so long as the laws of human nature turn all the difficultly won wealth into increased power of the few over the lives and labours of the many ?

In another respect Ruskin was vastly ahead of his own, not to say our own, time. He and Marx both fully appreciated the main contention of present day exponents of economics from the point of view of the creator and producer of wealth rather than that of the financier or merchant. The wealth of a community can only be increased by production and discovery, not by acquisition and exchange. In commerce and exchange " for every plus there is a precisely equal minus." But the pluses wax magnificent and the minuses retire into back streets or underground, " which renders the algebra of the science peculiar."*

This, then, is my main quarrel with orthodox economics, that it confuses the substance and the shadow. It mistakes debt for wealth and is guilty of the same mistake as the old lady, who, when remonstrated with for overdrawing her account, promptly sent her banker a cheque for the amount. The confusion enters even into the attempt of the earlier economists to define the main subject matter of their studies—" Wealth," though the modern economist seems to be far too wary a bird to define even that. Thus we find that wealth consists, let us say, of the enabling requisites of life, or some-

* " Unto This Last," John Ruskin, 1877.

thing equally unequivocal and acceptable, but, if it is to be had in unlimited abundance, like sunshine or oxygen or water, then it is not any longer wealth in the economic sense, though without either of these requisites life would be impossible.

Now it is the object of science to render the enabling requisites of life, such as food, warmth and other forms or embodiments of energy necessary for a decent existence, so abundant that they shall cease to be wealth in the sense of the economist. By increasing a real quantity you do not diminish it, nor by increasing it without limit do you destroy it. The object of science is to destroy wealth in the economist's sense of debt altogether by increasing real wealth without limit.

At the first blush and before they have had time to think, most youthful students of economics will probably tell me that I am playing with words by using the word wealth in two senses equally well understood by the economist. The fact is that the economist, ignorant of the scientific laws of life, has not arrived at any conception of wealth, apart from the elaborate code of enactments and legal conventions which give to the individual in actual non-possession of wealth the right to acquire it, whereas I, from the application of the laws of energy to the problem of how men live, have arrived at such a conception.

In conclusion, I may devote my attention to the commonest form of debt, money, because I believe that until correct views are more widely diffused about this convention, and the purchasing power of money is fixed as definitely as are the standards of weights and measures, there can be no peace in society and the whole elaborate political and social system will remain merely a dreary and elaborate make-believe.

Once more owing to the war, the real nature of money can be apprehended by anybody. It ought to bear precisely the same relation to the revenue of wealth as a food ticket bears to the food supply or a theatre ticket to a theatrical performance. Whereas, as a matter of fact, at present there is no more connection between the currency and the revenue than there is between the birth-rate and the barometer. The revenue depends upon the chances of the harvest, and all the causes such as the prevalence or absence of disease, tempests, drought and sunshine which affect the productivity of nature. The currency is, or was, left to the luck of the gold prospector, and his spasmodic discoveries, to the state of knowledge of extracting the precious metals in which a single innovation, such as

cyaniding, may enormously increase the supply, the invention of such a system as that of cheques, the solemn carting around of gold from one capital to another to concertina the prices up and down to suit the hierarchy who have made of money a mystery and of the currency a never-failing confidence trick.

Whereas, if money is to fulfil its function as a measure of value, it is clear that the currency must be regulated *pari-passu* with the changing revenue, issued as the latter expands and destroyed as the latter contracts. Since it would neither be given away in the first nor taken away in the second event, but used to buy back old, or taken in exchange for new State loans, the community as a whole would share the prosperity of good times as well as the stringency of bad ones, instead of only the latter as under the existing system.

I remember reading as a young man, in some book on economics which I have not since been able to trace, of the almost mystical virtues of gold in human welfare and how each successive discovery of that metal in California, South Africa and Australia was followed by a boom of trade and increased national prosperity. To a chemist the mystical virtues of any metal, even gold, seemed a wholly chimerical illusion, but I waited twenty years before the real explanation became obvious. Last century was a time, when, wholly beyond the understanding of those who lived in it, science was increasing the revenue of the world by leaps and bounds by the consumption of the store of energy preserved in coal. If the food supply is increased without a corresponding issue of new food tickets, every holder of an old ticket gets proportionately more. Whereas if the ticket issue is increased *pari-passu* with the food supply, the old ticket holders get the same as before and fresh people get the surplus of food. Hence every increase of currency in that flamboyant era of prosperity, whether it resulted from the discovery of gold-mines or the invention of cheques, meant that the increased prosperity did not go to the community's creditors, but a part corresponding with the increase of currency went to fresh people and general prosperity was the result. How much easier it would have been simply to print the money and use the issue to repay the National Debt. But the opportunity passed and the like may not occur again.

I shall be asked by those who are unaware of the proposals made by Gesell on the Continent and by Kitson in this country how is it possible to fix the purchasing power of money. The

answer is simple enough. By fixing it, that is, by printing more as average prices, determined by index numbers, tend to fall and by withdrawing it from circulation as they tend to rise. As it is, these matters, which are the most vital factors of all that enter into the economic welfare of the community, are left to the oddest combination of natural luck and human cunning to which, surely, any race ever entrusted its destinies.

Money, I shall be told, must function not merely as a measure of value, but as a medium of exchange and as a store of value.

As regards the latter, humanity is crying for the moon. Wealth is a flow, not a store. After the search-light of the war, I can conceive no nation so barbaric as to regard gold as a store of value. Demonetise it and where is its value? Not a gold mine would be at work on the morrow. The world has enough gold to stop its teeth and gild the inside of its tea-spoons for hundreds of years. Nor, as a medium of exchange, can anyone, after the experience of the war, really find any fault with paper, provided of course its issue were directed to the end of maintaining average prices constant from century to century.

Civilised nations maintain at great expense elaborate testing institutions to fix with meticulous accuracy and disseminate replicas of all quantities that enter *into one side* of every commercial transaction involving buying and selling. They maintain an army of officials and inspectors to suppress the hollow pound weight, the elastic yard-wand and the telescopic quart pot. What an elaborate fraud upon the public all this one-sided passion for accuracy is! The public are not interested in the absolute magnitude of weights and measures. What is solely of practical importance is the relative measure, not merely how much coal there is in the sack or how much beer in the mug, but how much coal and how much beer for how much money.

Do we keep a National Economic Bureau to stabilise the purchasing power of money and an elaborate organisation of inspectors, the counterpart of those who suppress petty fraud, to deal with organisations to concertina the pound sterling? Our system is precisely analogous to sealing up only one arm of a balance and making an imposing parade of protecting it from the wind and tamperers, while leaving the calibrating arrangements of the other arm to the manipulation of a class of persons deriving their livelihood from the business. It is

on record that a group of American financiers on one occasion, having sold British and bought American securities in advance, removed £11,000,000 from the Bank of England and put it into circulation in America, with the result that the prices of the securities they had sold fell greatly in value and those they had bought rose correspondingly. Since gold never constitutes more than a few per cent. of the total currency, a reduction or increase of the gold basis in a country is followed by an enormously larger total fall or rise of values, and financiers in the position to cart about a few millions of the "precious" metal at their will can very easily and certainly acquire other people's wealth.

No doubt the instance quoted is an extreme one, but when one enquires further as to who is in charge of the calibration arrangements that fix the purchasing power of money, much that has hitherto seemed inexplicable about our time becomes clear. These powers are wielded, by private banks, like the Bank of England, in the steadfast interests not of the community but of the creditors of the community. Whereas no changes of revenue, so long as the currency remains constant, affect the *relative* proportion of the whole revenue secured by the creditors, any increase of currency diminishes their relative share and hence is known as inflation, while any decrease increases their relative share, and hence is called sound finance.

Even so far as we have yet got in disentangling current misconceptions of wealth from reality, it is not difficult to understand why the blessings conferred by science have been of so limited incidence. Civilisation has been, in its most vital interests, not in the hands of those who have contributed most to its wealth, but of those to whom in a very literal sense it is indebted, and is likely, under this system, to become ever more indebted. This gives a short practical remedy for the most obvious of the ills that civilisation is heir to. Institute a complete organisation for ascertaining, on every public proposal, the feeling of the City, and the views of the captains of finance and banking, but act in precisely the opposite direction. From the point of view of the welfare of the community rather than of its creditors, you could hardly fail to be right every time.

SECOND LECTURE.—Chairman, Principal Senter.

SOME questions I was asked at the end of last lecture seem to indicate the necessity of first clearing away some misconceptions, partly, perhaps, due to my citing Ruskin as an economist. Although my views are very similar in some respects to those arrived at long ago by Ruskin, I may be permitted to remark that I have deduced them, without at the time being aware of Ruskin's writings on this subject, from the principles of the heat-engine, rather than from those of ethics. I know it is a burning question whether economics ought to concern itself with ethics at all, but of its obligation to understand the engineering of life I do not think there can be two minds. If it is a science at all, it is, in Huxley's words, concerned with truth as "veracity of thought and action, and the resolute facing of the world as it is when the garment of make-believe with which pious hands have hidden its uglier features has been stripped off." Neither the ethical nor statistical sides of make-believe are to-day of any very great interest, but economics has still to achieve the emancipation which, in Huxley's day, the biological sciences accomplished. It is just because the application of the every-day principles of engineering to the living engine offers such a powerful corrective to the make-believes of the economic systems of society that I have ventured to address you on the subject.

On the strength of a quotation from Ruskin, that there was no profit in exchange, Ruskin was condemned by one distinguished economist, I think unfairly. I am well aware that it is the fashion to regard Ruskin as out-of-date as an economist, though as a matter of fact the times are even yet hardly ripe for a judgment on this point. But on the actual statement that there can be no profit in exchange there can surely be merely a difference of meaning to be attached to the word *profit*.

There is much making of money but no making of wealth by exchange, much advantage to Society for which the merchant is highly remunerated, much acquisition by the merchant of wealth, but no profit, for the sum total of wealth is unaffected by exchange and against the merchant's plus there is a precisely equal minus.

The word economics was coined by Aristotle as signifying household management in contradistinction to money and trade (chrematistics). What Aristotle meant 2,250 years ago,

I pointed out again last lecture when I charged "economists" with confounding debt for wealth. A ham merchant working on what he is pleased to call a 10 per cent. basis of profit, may buy ten hams for the same sum as he sells nine. He may be pleased to think he has made a profit of one ham, but he certainly has not made a ham. There were and remain ten, whereas if anyone had made a profit of one ham, there should now be eleven. These hams represent the life-time profit of a certain number—$2\frac{1}{2}$ to be precise—of pigs, fed, according to nursery tradition, on the skins of potatoes, which in turn derived their feeding value from the sunshine. Wealth being some form of embodied useful energy, the law of the conservation of energy applies to wealth in that for every plus there is a minus. But fortunately in this case the earth is credited with the plus while the sun is debited with the minus, and that is as good as an actual creation of wealth from the terrestial point of view. Nearer than that the laws of matter and energy do not allow.

The *opposite* (for every minus there is a plus) is not true of wealth, because we are dealing with the availability of energy rather than with its total amount, and because of the natural tendency of all available or wealth-forming energy to pass, more or less quickly, into the waste heat of uniform temperature of the surroundings.

The exposure of the shams of economic systems is a time-consuming task, and, as we have still to consider the nature of capital and usury, it is as well first to say something about the realities. How is wealth produced and what, if any, are the limitations to the wealth of an intelligently directed community?

The first factor, a continuous flow of energy of an available form, has so far only been considered. If that were unlimited in amount and under human control in the same way as the energy of fuel now is, this factor would impose no limit on the production of wealth. Even the distinction which it is at present so necessary to make, between the life-use and the labour-use of energy, would be of less importance, for it is not so much that the synthetic production of food-stuffs, except by the aid of the plant, is impossible as that it is impracticable with energy at its present value. Last century it must have appeared, to any one following the line of thought we are pursuing, that the limitations of this first factor of wealth must

always limit human ambition and expansion. But now we know that it is not so. The extraordinary developments since the beginning of the century in the study of radioactivity and of the internal structure of the atom have proved that there is resident in ordinary materials amounts of energy of the order of a million times that which can be obtained from fuel during combustion, but that to liberate this store the transmutation of the elements one into another must first be made possible. The radioactive elements are in course of a natural transmutation, which, while it is impossible to stop, is likewise impossible to imitate. The energy of radium, the element which for thousands of years emits as much heat every two days as its own weight of fuel in burning, is derived from this hitherto unsuspected store of energy in the structure of the radium atom in its change into atoms of lead and helium.

No! it is the second factor in the production of wealth that now limits, and probably will always limit, human prosperity. It is knowledge, or rather ignorance. For untold years men froze on the site of what now are coal mines, and starved within sound of the Niagara that is now at work providing food. Every single factor in wealth production existed prior to the phenomenal expansion of the last century except one, the knowledge how to control and utilise for life the capital store of sunlight preserved in fuel. It is precisely the same to-day. We are as far from utilising the stores of energy, which we know exist all round us in unlimited abundance, as savage men, who had not yet learned how to kindle a fire, were from utilising the power which has made our own age great. The whole matter could not compete in public interest with a ball game or a prize-fight, and, as has been recently said, civilisation depends for its future on the long vacations when the scientific men in the Universities get the opportunity for a few weeks' uninterrupted and continuous research.

Although it is far from my own view of the matter to divide, as is sometimes done, the winning of knowledge into two water-tight compartments, pure and applied, academic and technical, or discovery and invention, and to elevate the former upon a pinnacle attainable only by the few and to depress the latter to a level only a little above the capacity of the ordinary efficient routine worker, it is undeniable that in point of time at least, pure scientific knowledge, acquired for the sake of knowledge only and with no definite utilitarian end

in view, must invariably precede any great advance in technology and invention. But in both fields the qualities of mind and temperament required are much alike, and in both, in their highest expressions, attain that undefinable and elusive quality we characterise as genius. All genius in this respect is alike—it creates, and in all creation the whole is invariably incomparably greater than the sum of the component parts. Those whose philosophy consists in passing by little steps, each almost trivial apparently, from the electron to the soul, try also to pass from the humblest beginnings of intelligence above the animal level to the present heights of intellectual achievement attained in the exact sciences. Genius to such is "only" the cumulative sum of infinitely little steps in intellectual progress which began with man himself. To my mind you might as well describe an old master as a cumulative effect of infinitely little daubs of paint, or a symphony of an accumulation of sound vibrations. The whole is greater than the parts, but even so, that is not the chief point that is missed. Everyone knows the difference between reading or translating a foreign language and speaking it. Some of us, who are being required now to spend a year of research work before taking the degree may realise the difference between knowing all about every important advance ever made in the subject of our study as well as or better than those who actually made these discoveries, and achieving the most infinitesimal advance therein ourselves.

Just as I am constrained to put a barrier between life and mechanism in the sense that there is no continuous chain of evolution from the atom to life, so I put a barrier between the assimilation and the creation of knowledge. Each one of these infinitesimal steps of intellectual progress which look so small in retrospect, once had a different character. Otherwise why, for example, was it left for Newton to discover the law of gravitation or Benjamin Franklin the nature of lightning? We have here a rather remarkable peculiarity of the human mind. Every teacher knows how apt his best pupils are to acquire and follow the achievements of the past and present, so that at the age of twenty they often may have a vaster range of knowledge than any of the pioneers who contributed to the subject. Yet how rare, so far at least, is it to find these uniquely equipped and finished repositories of knowledge capable of making a single step forward, that is not merely imitative, and

which a hundred years hence will survive to the honour of appearing trivial? Possibly we are on the eve of understanding something about the nature of intellectual creation as distinct from mimicry. But until we do, the wealth of the world, material no less than spiritual, has, ultimately, to be ascribed to the work of singularly few minds.

After energy and genius we come to Labour, the one factor in wealth production which hitherto has been adequately recognised. So far at least this factor has not limited the expansion of wealth, but rather expands *pari-passu* with it, though, in this respect, in all the European countries and also Australia, the increase of population appears definitely to have been checked. It is probable, at least of our own day, that any definite retrogression, as regards knowledge once attained, is unlikely, and even if civilisation has to pass through a time in the future analogous to the Dark Ages of the past, the intellectual achievements of the present day will remain preserved. Granted a certain stage in the technology of wealth production, it is probable that this, without any further aid from what I regard as the essentially creative type of mind, can be maintained from generation to generation by Labour in its widest sense, including in that term every kind and grade of routine and imitative worker, whether by hand or brain.

Thus we have three factors, two of the character of a continuous never-ending contribution, a flow of energy and the unremitting attention, whether physical or mental, required for its utilisation, and one, the creation of knowledge, of the character of a definite step forward made once and ever afterwards available for all time. The latter factor limits the rate of expansion of wealth but, strictly speaking, contributes nothing to its actual production. It will ever be the prerogative of genius to endow posterity rather than its own day.

More and more as time goes on, this character of wealth, essentially as a flow rather than something that can be stored, forces itself upon our attention as we grow out of the merely subjective views we derive from our own means of livelihood and bank balance. The time is fully ripe that the world should reconsider from a scientific basis the conventions by which it empowers individuals to "save" and amass "riches." Broadly, the object of such conventions should be definitely directed to provide for the period of childhood, adolescence and old age, for genius and for the dissemination and diffusion

of its results and for similar work of a publicly beneficial character. These must be charges on the revenue rather than debts handed on by private individuals to their heirs and successors and swollen by the ridiculous pretensions of the usurer to an absurdity.

With the growing appreciation of the general public, made wise because of the war, of the real nature of money, the much vexed question of what is usually called capital should not give us much difficulty. Just as money is a paper indent upon the revenue, capital is the paper receipt for the expenditure of wealth. Economists brought up on the mythical origin of man, as recorded in the book of Genesis, used to be fond of inventing, to explain the origin of capital, a mythical Robinson Crusoe, of exceptional industry and acumen, as the primitive capitalist. With the advance of knowledge the real Adam has turned out to be an animal, and now the original capitalist proves to have been a plant!

The material and scientific greatness of our day is due to the primitive accumulation of the solar energy of the forests of the carboniferous era, and preserved to this day as coal. The plant accumulated, we *spend*.

When coal is burnt it is burnt. You cannot both burn it and keep it in the cellar, and still less can you go on drawing interest from it for ever at so much per cent., as is the case with the so-called capital of the economist and the business world. Here again the economist is mistaking our old friend debt for wealth. The wealth has been spent, not saved, and exchanged for some form of receipt, giving the holder a purely conventional right to so much per cent. per annum until the debt is repaid.

The capitalist wishes to have it both ways, to be regarded as a public benefactor because he spends his wealth, not in drinking himself to death, but in enterprises designed to increase the revenue. If he did this he would indeed be a public benefactor. But the community having spent his wealth, as regards himself he expects it all back in due course with interest on the loan. The consequences of his abstinence are that civilisation has got inextricably "into the hands of the Jews." Compared with this, the wildest profligacy on the part of the original capitalist would have been a relatively minor evil.

It is of course a colossally hard task wisely to expend

wealth so as to increase the revenue. All honour is due to the business energy and enterprise of the commercial and technical managers and the workers who effect the conversion of capital wealth into increased revenue. But as regards the people who merely lend the wealth spent, the ordinary dividend holder of a joint-stock company for example, he is of course simply that peculiar type of benefactor which used to be termed a usurer. We are all in it now, ever since it became possible to buy a £1 War Saving Certificate bearing compound interest for 15s. 6d. The extraordinary changes of legal and social conventions with respect to interest and usury, recorded in history, make it quite clear that political economy, which depends upon such factors quite as much as upon the laws of energy, can never be a science in the same exact sense as physics or chemistry. To Aristotle a usurer was a person beneath contempt. To-day, even the Vice-Chancellors of the ancient Universities, which purport to hold up to reverence Greek thought and culture, are as enamoured as anyone of the excellence of compound interest.

Of all hard critics of the usurer, Martin Luther is easily first, and in his vigorous denunciation there is a certain perspicuity which we moderns seem to lack. Otherwise few could tolerate the economics of an ordinary daily newspaper or social club.

> "The heathen were able by the light of reason to conclude that a usurer is a double-dyed thief and murderer. We Christians, however, hold them in such honour that we fairly worship them for the sake of their money. . . . Usury is a great huge monster, like a were-wolf, who lays waste all, more than any Cacus. . . . For Cacus means the villain that is a pious usurer and steals and robs and eats everything. And will not own that he has done it and thinks no one will find him out, because the oxen drawn backwards into his den make it seem from their footsteps that they have been let out. So the usurer would deceive the world as though he were of use and gave the world oxen while he however rends and eats all alone."

One must admit that it would be difficult to find a better description of usury than is given here, "Oxen drawn back in to the den which, from their footsteps appear to have been let out." Current orthodox economics gives the credit that

rightly belongs to the scientific discoverer, the expander of wealth, to the usurer, the expander of debt.

I shall be told that there is something to show for capital expenditure and that against the paper receipts there are tangible assets. Thus, if a railway is taken as an example, there are the rolling stock and the rails. But admittedly these would have but a scrap metal value if railways ceased to pay and the shareholders wanted their money back. As the world gets older all this initial expenditure has to be periodically renewed to make good depreciation, and, further, the plant and the methods of operation become, with the advance of knowledge, out of date. The indebtedness to the original shareholders does not, however, usually cease on that account. Railways continue to pay dividends on all capital expended, though, as in the case of the canal systems purchased, much of it altogether ceases to bring in revenue. It seems to me to be merely a matter of time before this happens with every form of capital expenditure. The normal old-age form of capital is simple debt, a permanent lien upon the future revenue of wealth. The assets are much overrated. If the world worked as hard on construction as it did during the war on destruction, and was permitted by the usurer to do so, all civilisation could probably be rebuilt upon an up-to-date plan and the Augean stable of a modern industrialised community cleaned up in less time than the war took.

The vast heritage of wealth which science made available at the commencement of the 19th century, in so far as it has been spent, has been replaced by paper receipts for the expenditure which bear interest in perpetuity. Capital merely means unearned income divided by the rate of interest and multiplied by 100. If I invent a process bringing in £1,000 a year revenue, its capital value is £20,000 if the rate of interest is 5 per cent., and I can sell it for some such sum. The capital of the world in this sense to-day aggregates to an altogether inconceivable sum. *There never has existed at one time such an amount of wealth.* It represents the accumulated capital expenditure of generations of men. During the war the capital of the country was *increased* by some £7,000,000,000, which brings in £350,000,000 a year permanent interest. I may be told that everyone will admit that this is debt, whereas it is in fact, in this respect, precisely on the same footing as so-called productive capital expenditure, a private lien upon

the revenue, *wealth* to the individual owner and debt to the community. As regards the national accounts this £350,000,000 a year is a simple transference, rather than an item of expenditure. The sum is collected from the taxpayer, and paid to the holders of War securities. It amounts to £8 13s. 4d. per head of population, and includes the small item of 10s. per head in respect of the Napoleonic wars. There can be only one possible end to this process. Though for a time the advances of science may so increase the revenue from year to year as to render these payments by way of interest possible, in the end the whole of the revenue must be in the control of the usurer. A small part of the population will get into the position of a great rentier class living on interest, and most of the rest will be reduced to starvation in so far as they are not kept alive by State doles. How far this process has already gone in this country is obvious, since something like a quarter of the population at the present time is unemployed and the expenditure on national education is only about a quarter as much as that upon the holders of war securities.

Wealth is a flow and it cannot be saved. Spent it must be as it accrues, whether on consumption or on capital outlay designed to produce future wealth. As regards the first, *life is consumption* from the cradle to the grave, consumption of that pristine flow of energy we owe to the sun. The efforts of the financier and monied person to make life a balance-sheet with the debit and credit sides in agreement are untrue to nature. Life is a continuous expenditure of wealth and in this point again Ruskin, rather than the modern chrematist, was absolutely in agreement with science. And, as regards the second, capital expenditure, even though it is designed to increase the flow of wealth, and admittedly, over a certain natural period which is *not* infinite, it does achieve this object, it is expenditure as much as the other. The river of wealth is thus divided, but a part is metered carefully and recorded as an accumulation of capital indebtedness against the community. Scientific men, in the innocence of their hearts and the benevolence of their souls, fondly imagine that by increasing the revenue available for life they benefit the community. But do they? The larger the revenue, and the greater the flow above that required for immediate consumption, the greater the debts incurred by the community and the impossibility of their ever being repaid. Meantime, though real

wealth rots if stored, the meter readings spontaneously bear interest and increase *ad infinitum*. The principles and ethics of human conduct and convention have their own code and standards, but whatever they may be, they must conform to and not run counter to the principles of thermodynamics. A chauffeur may have a soul above the mechanism of his car, but if it led him to try to run it on already consumed petrol, none the less he would be considered a great ass.

The usurer in Martin Luther's time had not achieved the colossal success "in deceiving the world as though he were of use and gave to the world oxen" that he can claim to-day. The professional economist seems to be an easy conquest. Thus Mr. J. M. Keynes, in his "Economic Consequences of the Peace," seriously seems to think that the law of compound interest is the law of increment of wealth rather than that of debt, and offsets it against the Malthusian law of increase of population! "One geometrical ratio might cancel another and the 19th century was able to forget the fertility of the species in a contemplation of the dizzy virtues of compound interest." To him capital is a vast accumulation of fixed wealth, *in danger of being prematurely consumed in war*. He likens it to a cake, which one day, owing to the dizzy virtues of usury, may be large enough to go round. "In that day overwork, overcrowding and underfeeding would come to an end, and men secure of the comforts and necessities of the body could proceed to the nobler exercise of their faculties." Cake happens to be the one material of which it has been well said that you cannot eat it and have it too, and I would suggest that this is the real reason for Mr. Keynes's somewhat mystical references to a peculiarity of capital considered as accumulated cake, that this "is only in theory—the virtue of the cake was that it was never to be consumed." In a similar vein we have Major Douglas and Mr. Orage advocating the salvation of the economic system by the bringing of the dizzy virtues of dividends within the reach of the many rather than of the few. I do not mean to imply that their system might not be a great improvement upon the present one. Indeed, any system almost must be an improvement upon one that is administered solely in the interests of the creditors, rather than the creators and consumers of the community's wealth. But my analysis would lead me to class their suggestion rather as a temporary palliative, for no system founded upon usury can be stable.

It is wonderful how people, who never come up against reality from the cradle to the grave, and live all their lives a purely artificial existence in some city divorced from all contact with primitive nature, get into the habit of supposing that the conventions which regulate their businesses and livelihoods can be applied to the economy of the world at large. It would be quite impossible for any member of the agricultural community, for example, accustomed to the ways in which wealth is really produced, to fall down and worship the institution of usury in such a naive fashion, or for a Labour Government, to be guilty of the confusions between wealth and debt which are characteristic of orthodox politicians at the present time. We have in the hitherto association of the function of Government almost entirely with those who live by rent, interest and profit, and thus take from rather than contribute to the revenue of the wealth of the community, a further justification for the view already expressed, that the community in its struggle for existence resembles an army officered almost entirely by the enemy.

You cannot permanently pit an absurd human convention, such as the spontaneous increment of debt, against the natural law of the spontaneous decrement of wealth. This applies whether it is simple or compound interest which regulates the increment of debt. For obvious reasons the law of compound interest over great periods of time rarely as yet has fully operated. But the significant and distressing fact is that this absurd law, with the concentration of money in the hands of trusts and combines of financiers, now tends to operate more and more fully every day. Some of you may have heard of the story of the reward asked of the Emperor of China by the man who taught him chess. It looked modest enough. He wanted one grain of corn for the first square of the chess-board, two for the second, four for the third, eight for the fourth, and so on in a geometrical progression to the 64th square. The story goes that the first half of the board was easily accounted for, but before three-quarters had been so dealt with, the Emperor had to cry off, as his couriers came back to him reporting that there was not such a quantity of corn (actually 23 million tons) in the Empire. If the matter had been pushed to the bitter end, at the 64th square, the number of grains would have been one less than 2^{64}—just about one million million tons—more than the present population of the world could consume in a period of time longer than that covered by the records of history. This is the law of compound interest. To-day £1 of debt doubles itself in about 12.5 years, and becomes £1,024 in 125 years and over a million in 250 years at 5.5 per cent. compound interest. If this is to be the inevitable consequence of scientific men increasing the wealth of the world, enthusiasm in well-doing may well dry up. Nevertheless, on no other terms than a perpetual increase of the revenue by scientific discovery can such a system of "economics" be maintained, and, even so, were the 20th century as prolific in discovery as the 19th, there is no escape for it from ruin under the law of usury and the rule of the usurer.

Let us, in conclusion, put in the light of the analysis of wealth and wealth production which has been attempted, the aspect of this mad system which is now uppermost in the minds of many thoughtful people, its inevitable end in world-war. Remember that it is impossible to save. The revenue of wealth must be spent as it acrues either in consumption or in capital expenditure. The latter is for the purpose of securing a lien on the future revenue, by producing more goods or services out of which a profit can be made. But as the masses do not receive the profit, they cannot buy this increased production. It was the discovery of the classical economists that wages are the purchasing power necessary to maintain a supply of labour, that is to provide food and shelter for the labourer and his family in the particular condition of life necessary and customary for that kind of labour. Man-power is now cheapened by being pitted against the infinitely greater and more docile power of inanimate nature. For a brief period, which is now closing, though only after terrible hardship and suffering, the displaced labour found an outlet ultimately by reason of the increased fraction of the revenue devoted to capital expenditure. But the world fills up. Its markets, at first open to the excess production of the industrialised nations in exchange for food, tend to close as time goes on. The fiercest international rivalry for markets ensues, and to industrialised nations armaments are, as products of machino-facture, the one thing that can be turned out in almost limitless abundance. But armaments and war do not produce food. They merely determine the distribution as between competing nations, and tend to destroy food-producing power to an extent that makes

even the victors actual losers. In this Ruskin was again far ahead of his own times. He alone seems to have had sufficient veracity of thought and power of penetrating below the conventions of society to realise that, in the frenzied pursuit of gain, the objective was illusory in a physical sense.

> "Capital is a root which does not enter into the vital function till it produces fruit. Capital producing nothing but capital is root producing root, bulb issuing in bulb, never in tulip. The Political Economy of Europe has hitherto devoted itself to the multiplication of bulbs. It never saw nor conceived such a thing as a tulip. Nay! boiled bulbs they might have been, glass bulbs—Prince Rupert's drops consummated in powder—well if it were glass powder and not gunpowder."

I do not pretend to be able to have got further in my own conclusions than this, that the rule of the usurer in political and social affairs has become impossible and that he has to go. During a time of expanding revenue, or before the burden of interest charges on the revenue from accumulated debts equals the annual expansion, he may be an efficient, if brutal, task-master, and the lure of private interest and gain may be a safe principle in place of government. But at a time like the present, when the usurers of the world, if cheated of their expectations, like Shylock are bent on a pound of flesh next to the heart, their pretentiousness and futility is obvious, and some form of government according to economic, rather than chrematistic, principles will have to be resumed. The laws of energy under which men live furnish an intellectual foundation for sociology and economics, and make crystal clear some of the chief causes of failure not only of our own but, I think also, of every preceding great civilisation. They do not give the whole truth, but, in so far as they are correct to physics and chemistry, they cannot possibly be false. I think with but little amplification and modification they might furnish a common scientific starting point from which all men concerned with the public rather than with their own private interests might start to rebuild the world more in conformity with the great intellectual achievements which have distinguished the present age. The first step towards such a scientific Utopia would be the due delimitation of the rights of the community's creditors—the curbing of the demon of debt which masquarades among the ignorant as wealth.

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